

PSYCHOLOGY 305

COGNITIVE PROCESSES

Agenda: Memory (p378~p412)

Quiz

1. Memory systems
2. Amnesia
3. Recollection vs familiarity
4. Beyond episodic memory
5. False memory and memory distortion

Think, pair, share

Do you think this is possible?



Gabriel, a US Cyber Command agent, with supercomputer chip implanted in his brain to interface all US intelligence data
--Intelligence (CBS)

"I know kung fu."
-- Neo in 1999 film "The Matrix."
after the martial art is "uploaded" to his brain

Can we implant memories?

Yes, if we can localize memory storage in brain?

Creating a False Memory in the Hippocampus

2013 Science

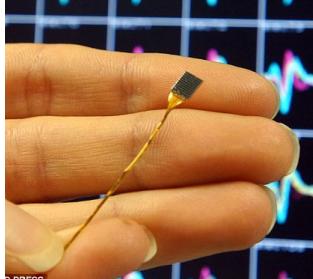
Steve Ramirez,^{1,*} Xu Liu,^{1,2,*} Pei-Ann Lin,¹ Junghyup Suh,¹ Michele Pignatelli,¹
Roger L. Redondo,^{1,2} Tomás J. Ryan,^{1,2} Susumu Tonegawa^{1,2†}

Memories can be unreliable. We created a false memory in mice by optogenetically manipulating memory engram-bearing cells in the hippocampus. Dentate gyrus (DG) or CA1 neurons activated by exposure to a particular context were labeled with channelrhodopsin-2. These neurons were later optically reactivated during fear conditioning in a different context. The DG experimental group showed increased freezing in the original context, in which a foot shock was never delivered. The recall of this false memory was context-specific, activated similar downstream regions engaged during natural fear memory recall, and was also capable of driving an active fear response. Our data demonstrate that it is possible to generate an internally represented and behaviorally expressed fear memory via artificial means.

ENGINEERING

J. Neural Eng. 8 (2011) 046017 (11 pp)

DOI: 10.1088/1464-226X/8/4/046017



A cortical neural prosthesis for restoring and enhancing memory

Theodore W Berger¹, Robert E Hampson², Dong Song¹,
Anushka Goonawardena², Vasilis Z Marmarelis¹ and Sam A Deadwyler²

What is Memory?

Memory proper is

-the knowledge of a former state of mind after it has already dropped from consciousness

-the knowledge of an event, or fact, of which meantime we have not been thinking, with the additional consciousness that we have thought or experienced it before.

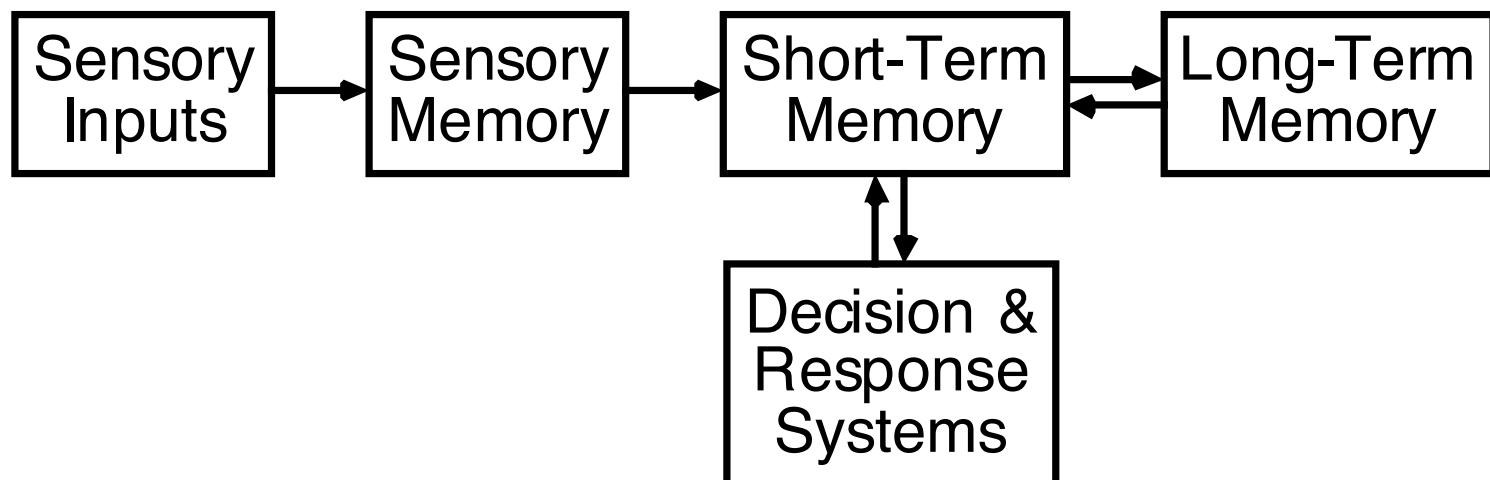
William James (1892)
Principles of Psychology

Parking ~ Memory Systems

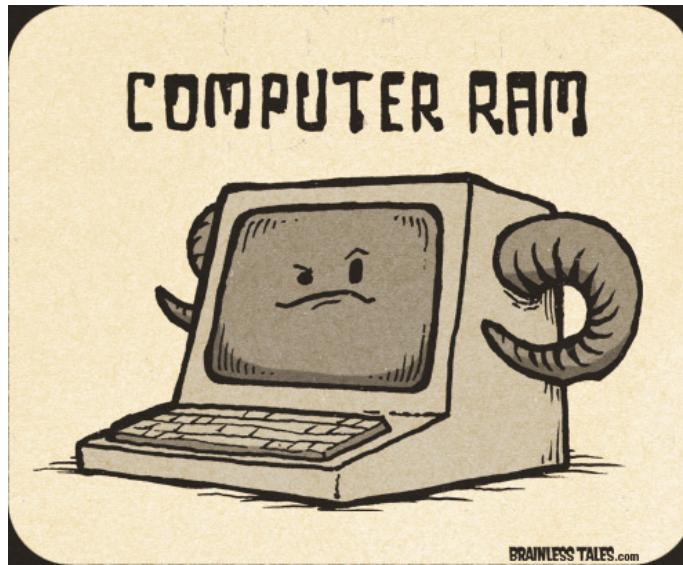


The Modal Model of Memory

- Atkinson and Shiffrin (1968) proposed a model of memory that was widely adopted and was later called the “modal model” of memory



Computer Analogy



Computer Analogy

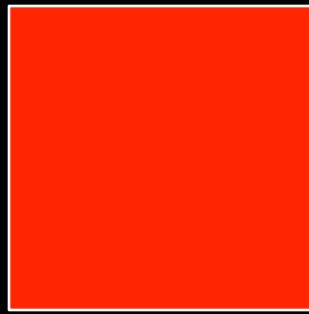
- Alan Baddeley and Graham Hitch (1974)
- STM is like a computer's internal memory (RAM)
 - Amount of memory is highly limited
 - Extremely fast, direct access based on pointers
 - Useful for fast online computations
 - Gone when power off (if not saved to hard drive)
 - Ever lost a file when computer crashed?
- LTM is like external storage (tape, hard drive)
 - Amount of memory is very large
 - Slow access via internal memory
 - Useful for retaining information for later use, e.g., tests

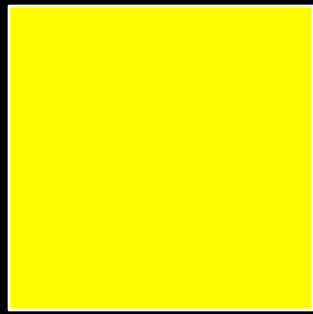
Limited Capacity of STM

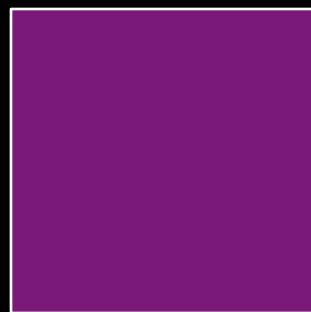
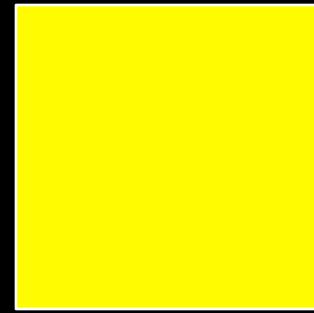
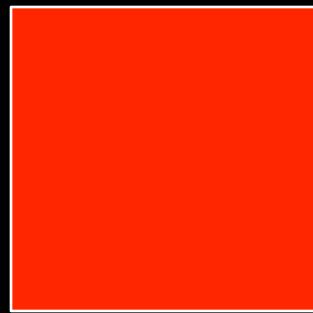
- “The Magical Number 7, Plus or Minus 2” (Miller, 1956)

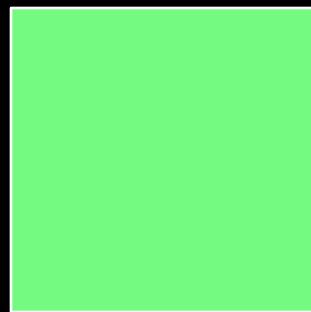
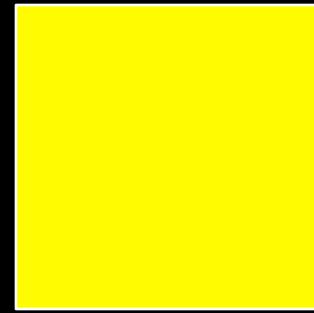
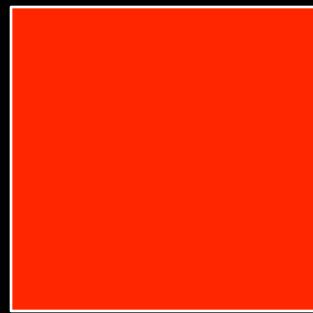
Change Detection Demo

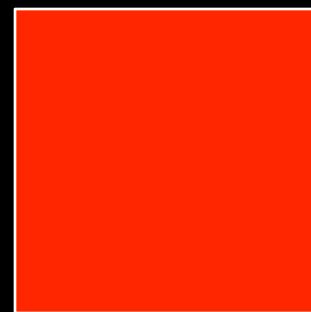
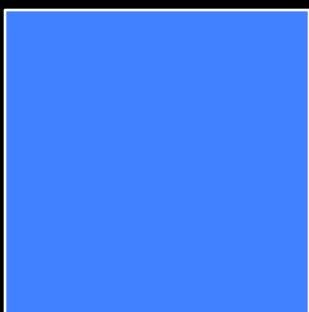
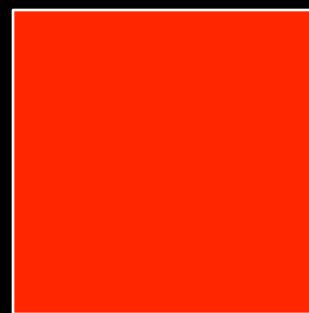
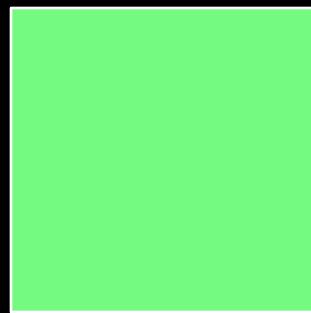
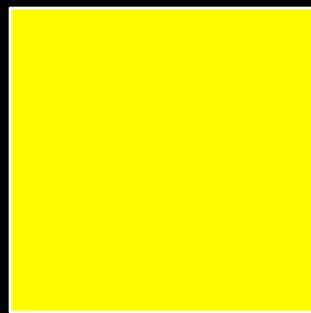
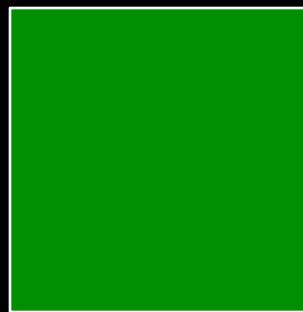
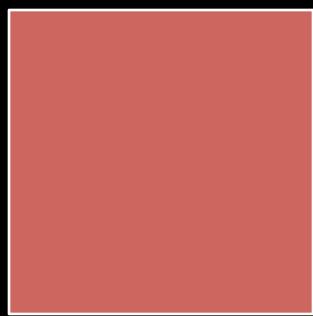
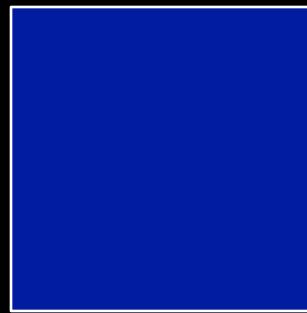
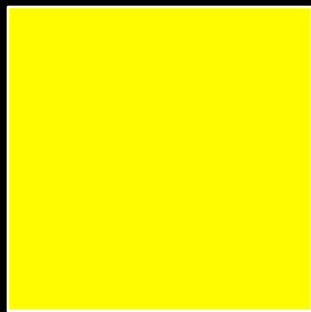
Find a changed color between two sequential displays of color squares

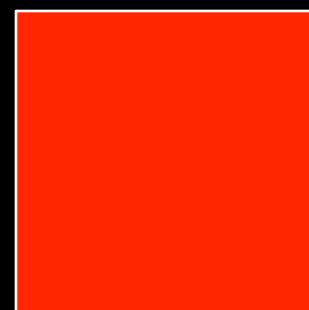
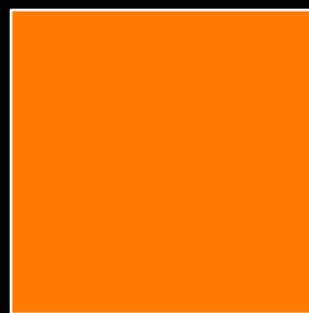
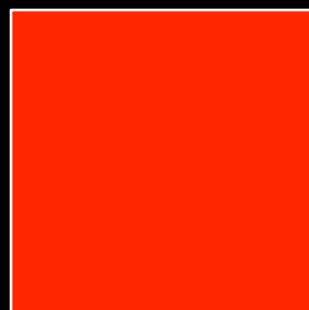
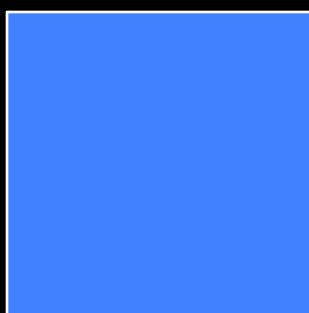
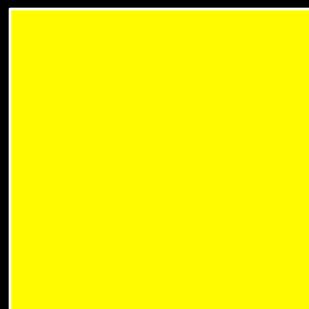
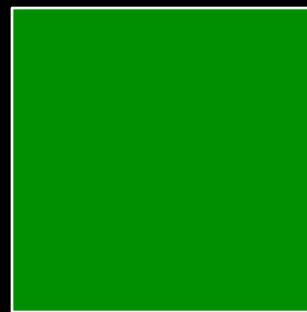
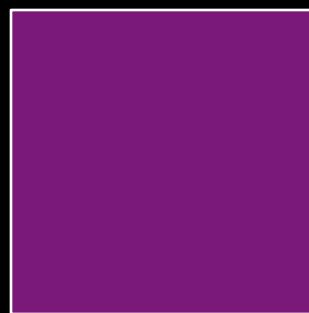
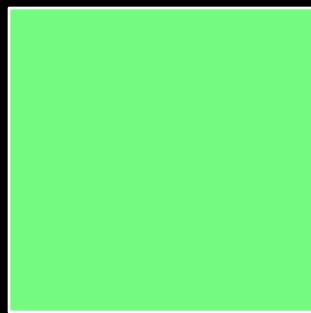
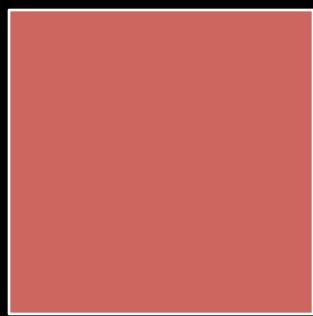
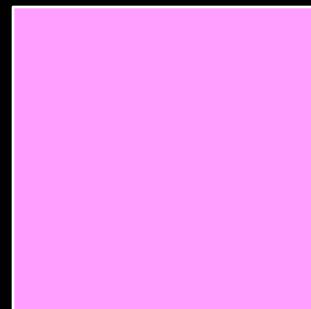
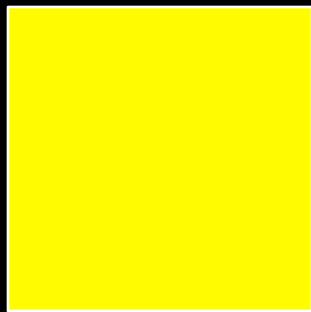






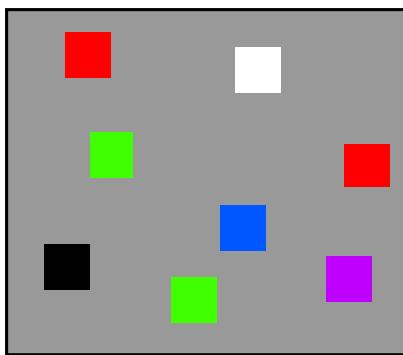




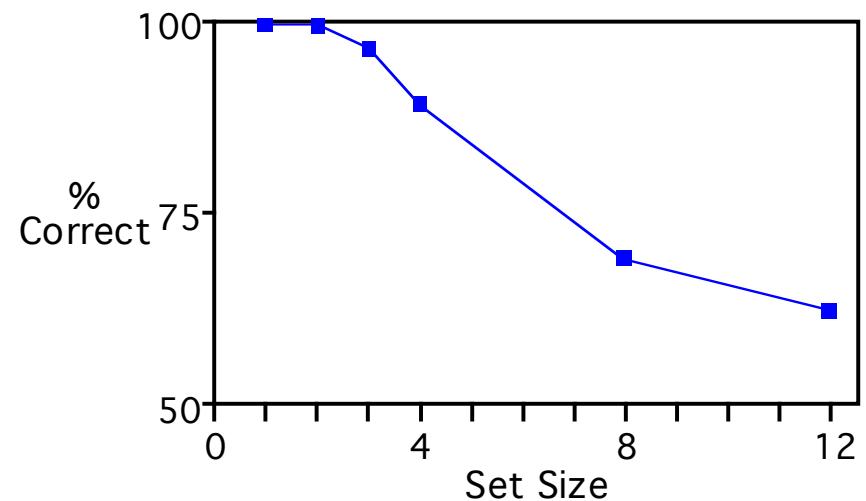


STM Capacity

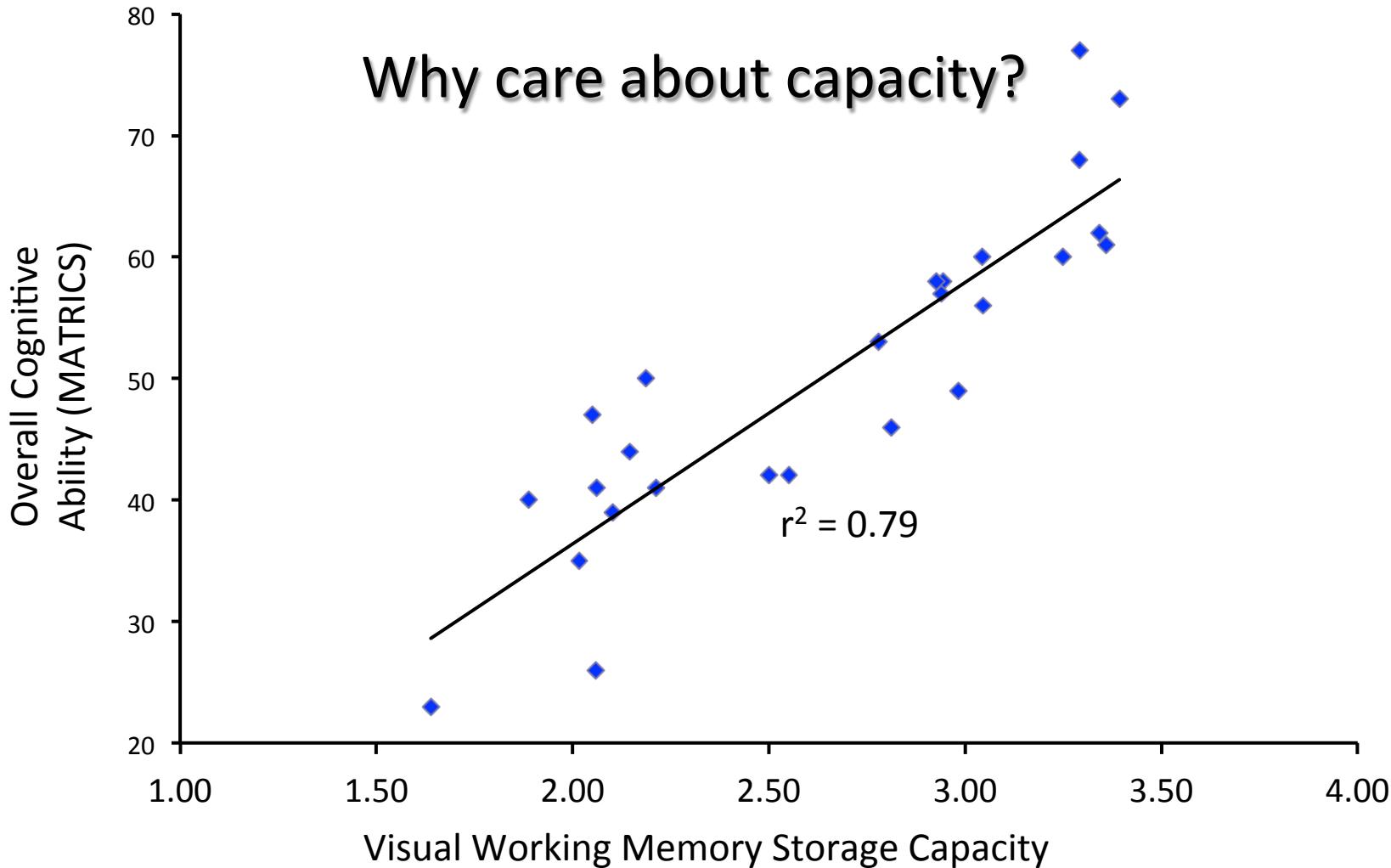
Memory Array
(100 ms)



Luck & Vogel (1997)



Capacity and Cognitive Ability



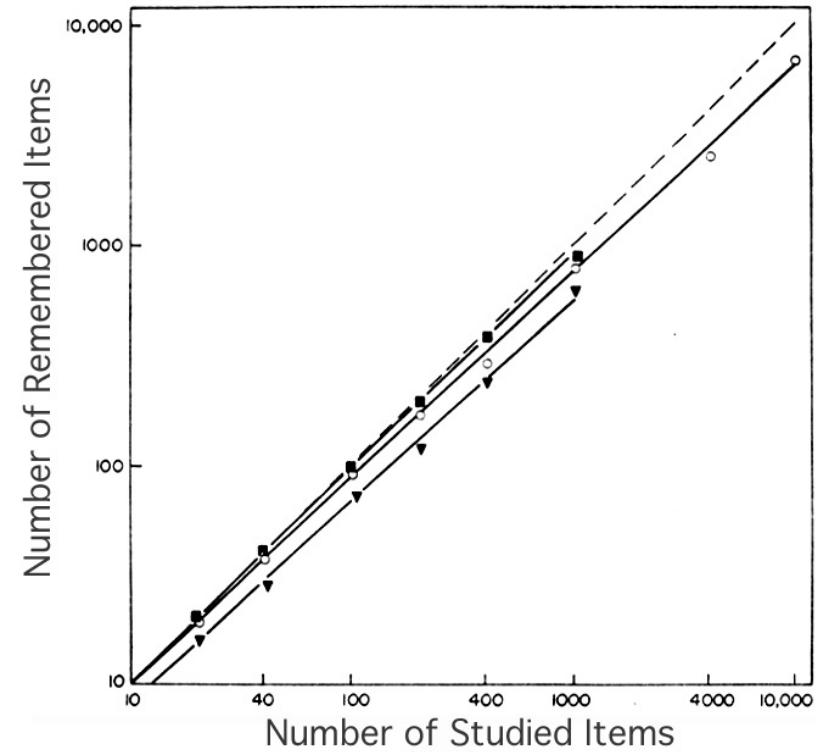
Virtually Unlimited-Capacity of LTM



"Mr. Osborne, may I be excused? My brain is full."

Capacity of LTM

- LTM capacity is virtually infinite
 - Standing (1973) asked subjects to memorize between 20 and 10,000 pictures and gave them a forced-choice recognition test 2 days later
 - He found almost perfect retention regardless of the number of study items



See also Shepard, 1967; Voss, 2009

STM & LTM differ in how much information can be stored

Next, how long is the information stored?

STM: short-lived

THE FLYING McCOYS

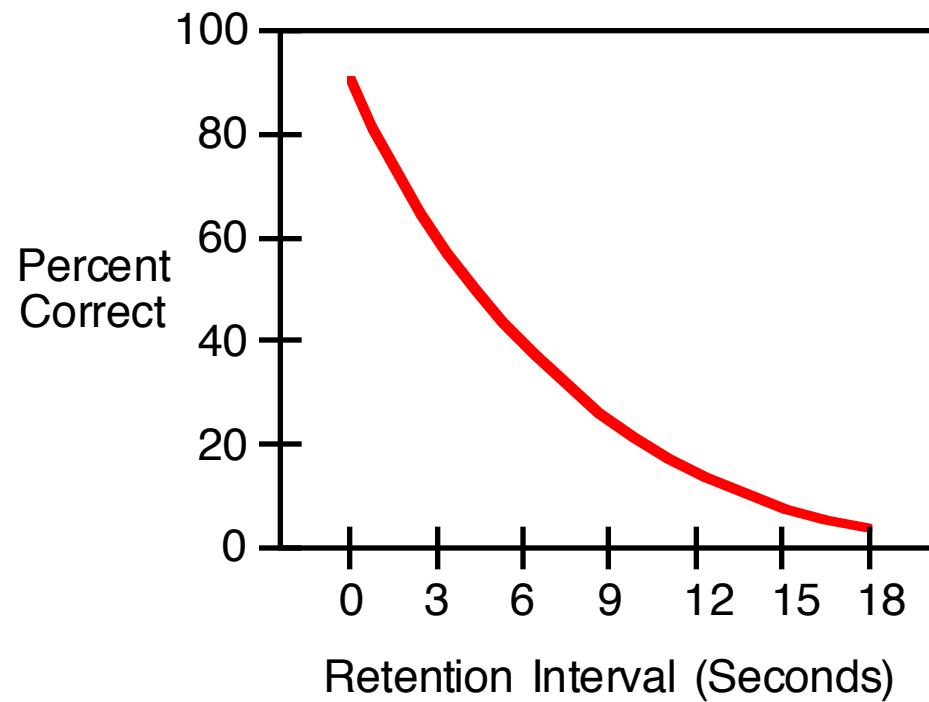
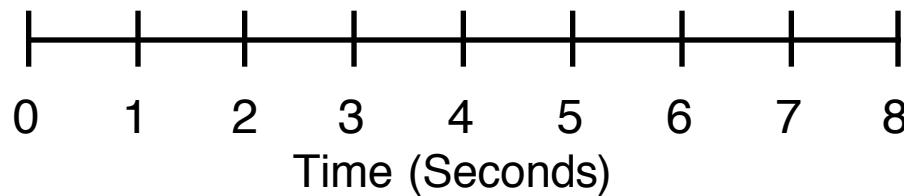
BY GARY & GLENN McCOY



Gradual Decay in STM

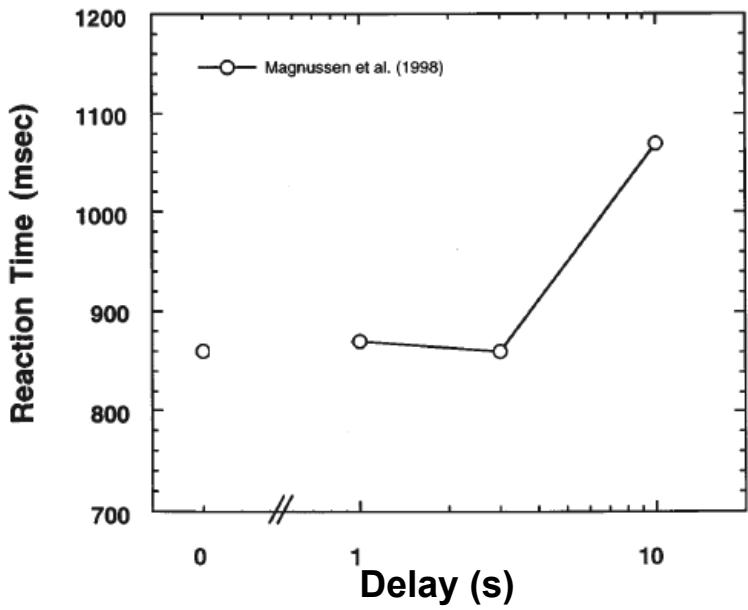
Subject
Experimenter

CHJ 506

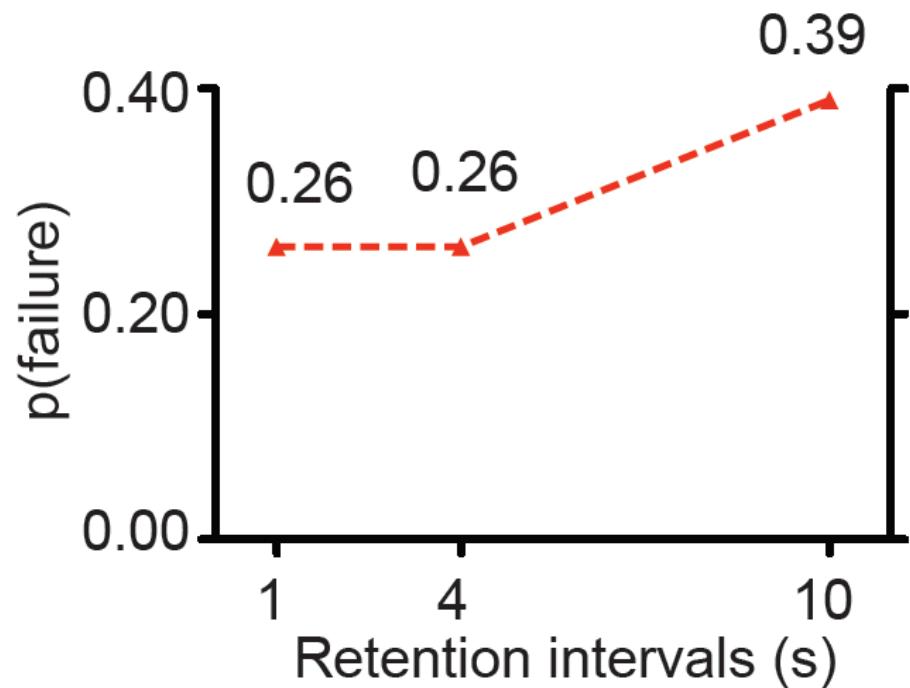


Sudden Forgetting in STM

Information maintained in STM for a few seconds



Magnussen et al. (1998)



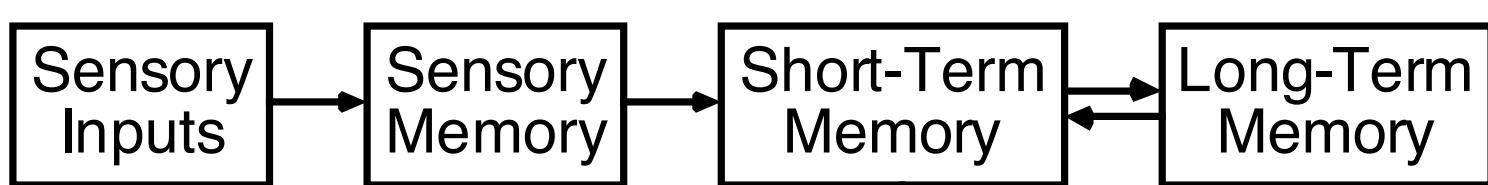
Zhang & Luck (2009)

Durability of LTM

- Lifetime memory
- Forgetting in LTM may be entirely due to retrieval failure rather than complete loss of information
- Analogy: Searching for information on the Web
 - Information is stored somewhere (e.g., Google server)
 - If you don't use the right search terms, you won't find what you're looking for (cues)

Summary

Modal/stage model
(Atkinson and Shiffrin, 1968)

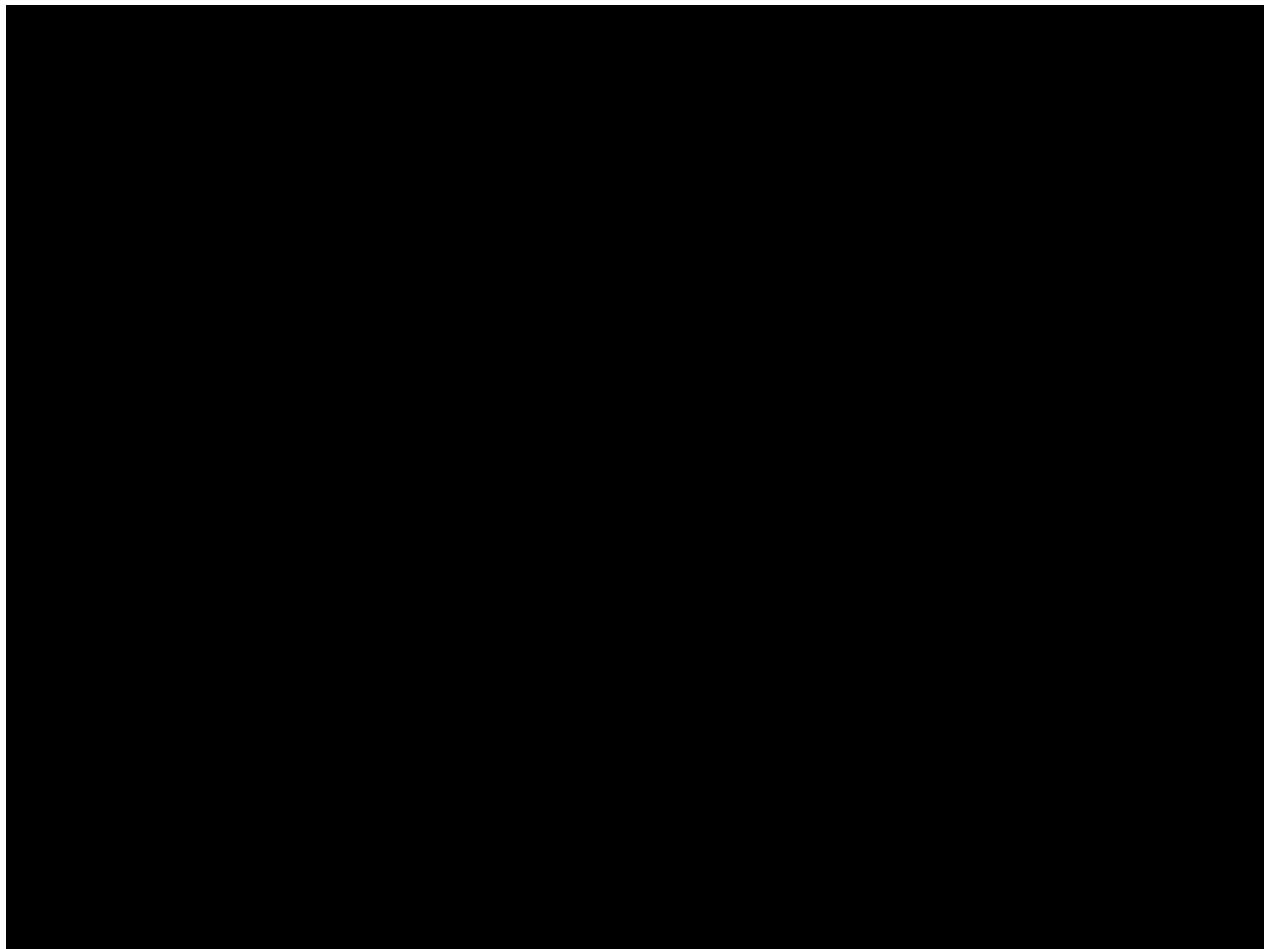


| | STM | LTM |
|----------|--|----------------------------------|
| Capacity | Limited (~3) | Unlimited Standing (1973) |
| Lifetime | Limited (forgetting after a few seconds) Peterson & Peterson | Unlimited (retrieval problem) |



Clive Wearing

The Man with a 30 Second Memory



Clive Wearing

- Damage due to herpes encephalitis
- Damaged bilateral hippocampi, surrounding temporal cortex, and some frontal.
- Kept diary that had repeated entries such as, *“now I am really completely awake”*, with the similar previous entry crossed out.

Amnesia – loss of memory



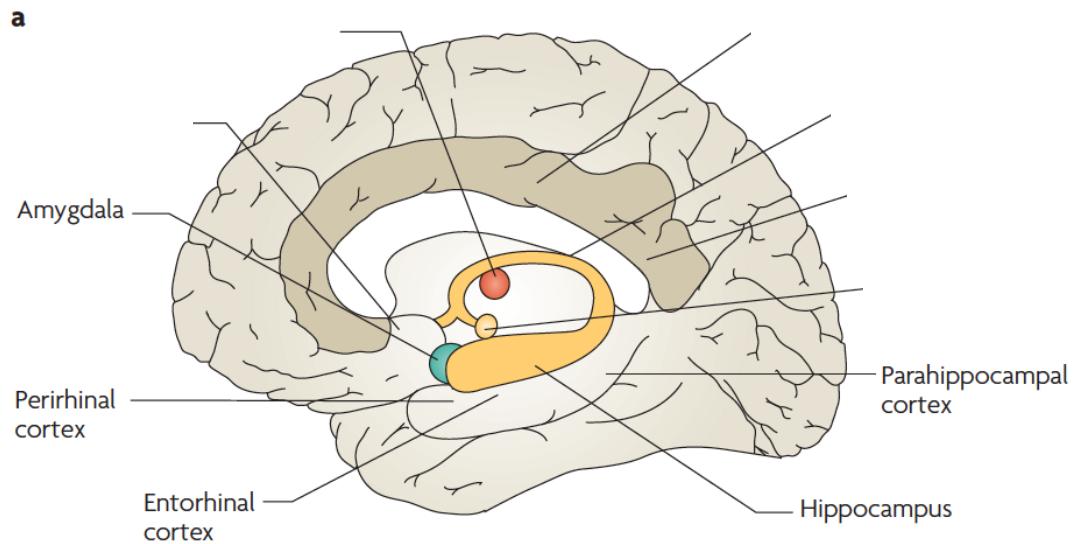
- Retro – before
- Antero - after

Amnesia

- loss of recent memories
- "Soap-Opera Amnesia": The claim of total amnesia for the past along with the intact ability to store new memories (e.g. *The Bourne Ultimatum*).
 - pure retrograde amnesia
- Real Life: People generally have partial recall of memories for events prior to the amnesia onset, but their ability to form new memories is impaired (e.g. *Memento*).
 - anterograde amnesia, with some retrograde amnesia



Structures of memory: Medial temporal lobes



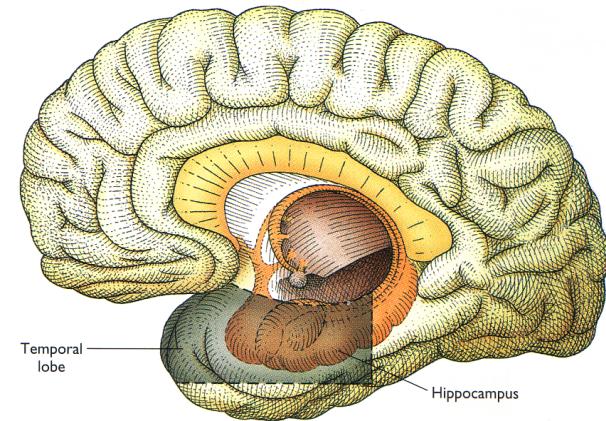
- Hippocampus
- Parahippocampal gyrus
 - Entorhinal cortex
 - Perirhinal cortex
 - Parahippocampal cortex

Amnesia Case Study: HM

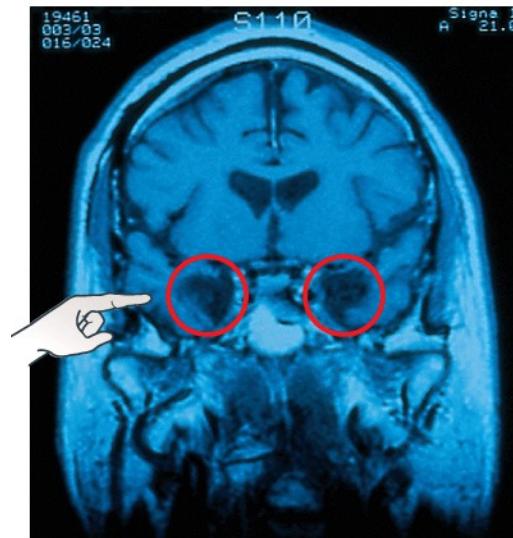
- Henry Molaison (Patient H. M.)
- Suffered from extreme epilepsy

Bilateral mesial temporal lobe resection extending 8 cm. back from the temporal tips, including the uncus and **amygdala**, and destroying the anterior two-thirds of the **hippocampus** and **hippocampal gyrus**

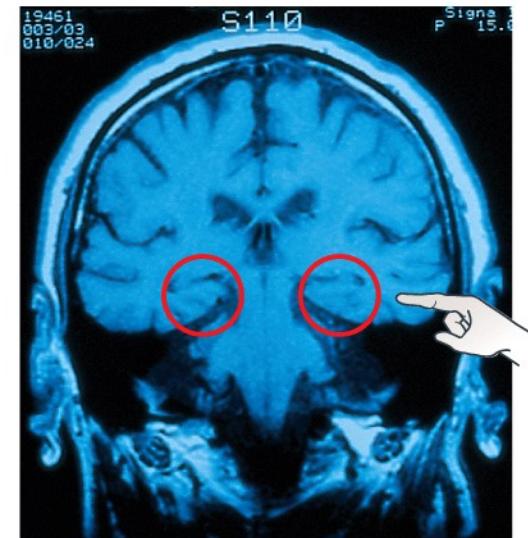
- Scoville & Milner (1957)



a Anterior

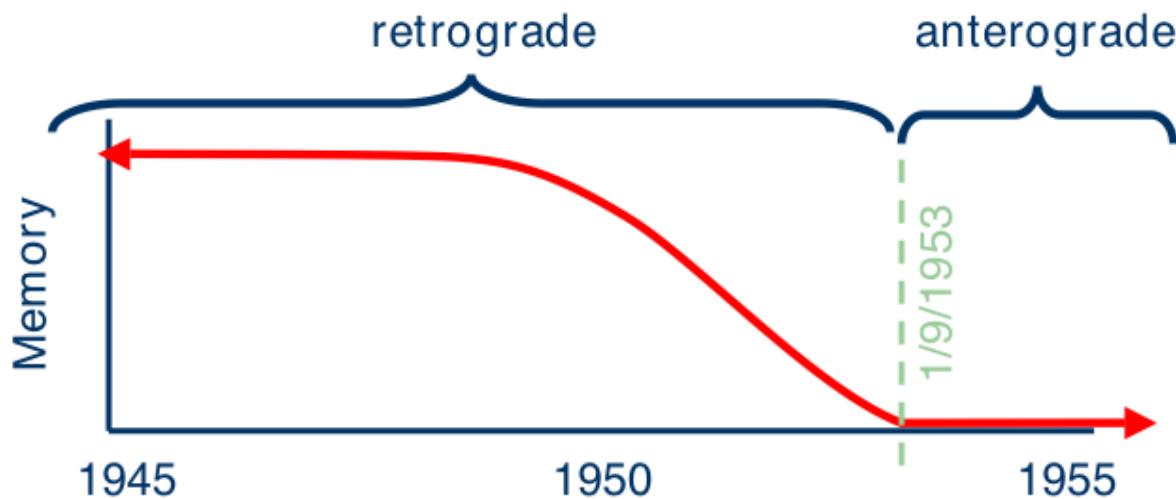


b Posterior



Amnesia Case Study: HM

- Unable to form new long term memories (anterograde amnesia);
- Some loss of events 1-3 years prior to surgery (retrograde amnesia)
 - consolidation



Amnesia Case Study: HM

- Intact: IQ, language, attention, knowledge base, childhood memories (from distant past), short term and working memory (normal digit span)
 - He can carry on a conversation
- No ability to form new episodic memories:
- *"Right now, I'm wondering. Have I done or said something amiss? You see, at this moment everything looks clear to me, but what happened just before? That's what worries me. It's like waking from a dream"*



H.M.

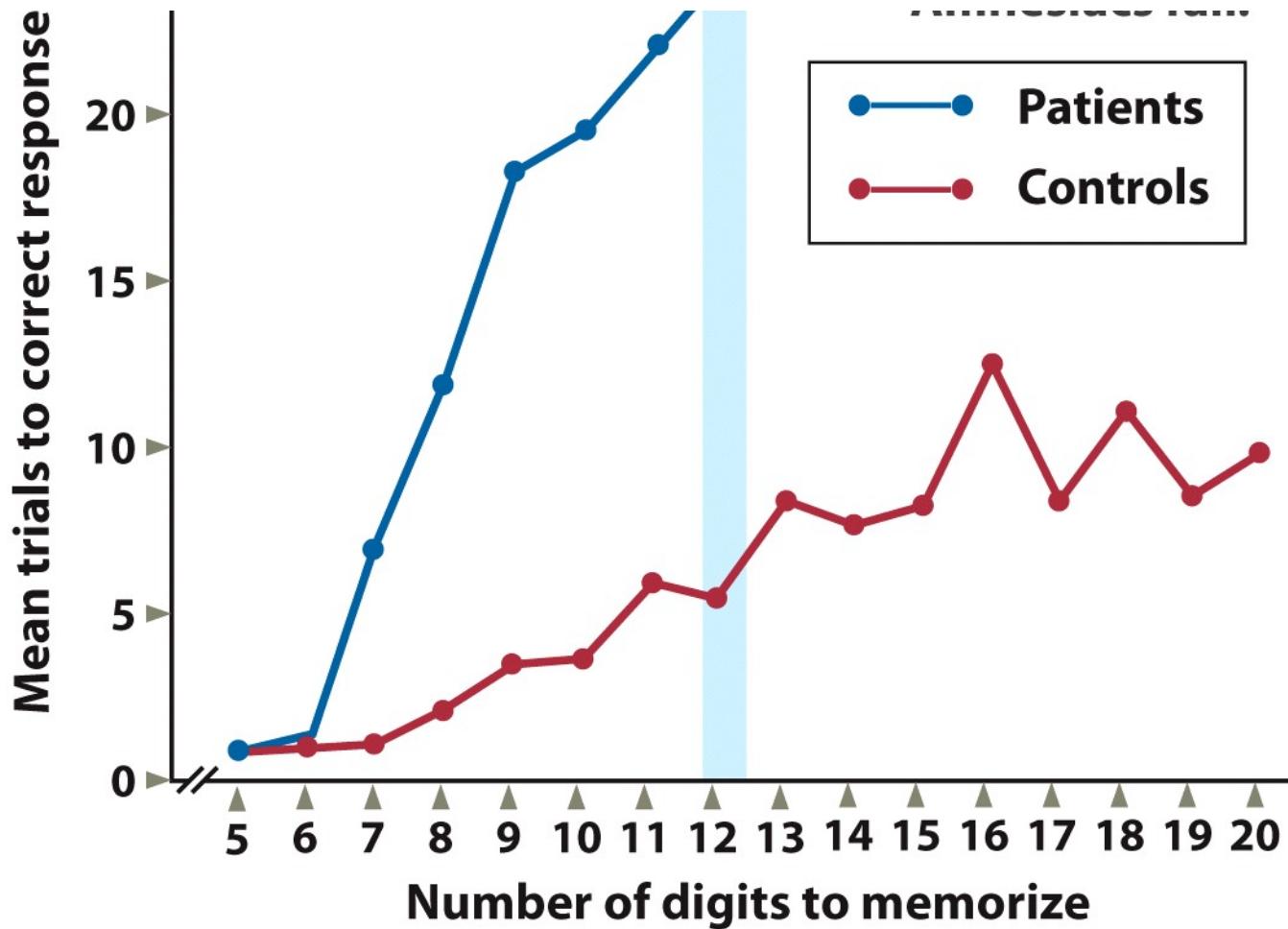


Project HM

- The most famous amnesiac H.M.'s brain has been sectioned and preserved for scientific study at UCSD
- HM's brain on Google Maps
 - https://thedigitalbrainlibrary.org/hm_web
- "SCIENTIA NOVA" ON MEMORY
 - <http://thebrainobservatory.org/hmvideos>

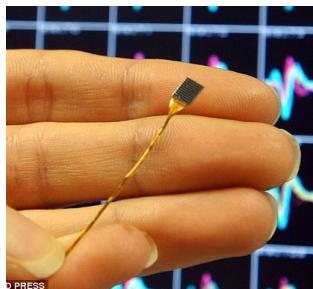


Intact STM



Memory encoding & retrieval and MTL Intervention is possible

implanted chip



Optogenetics, using light to turn on and off neural activity



IOP PUBLISHING
J. Neural Eng. 8 (2011) 046017 (11pp)

JOURNAL OF NEURAL ENGINEERING
doi:10.1088/1741-2560/8/4/046017



A cortical neural prosthesis for restoring and enhancing memory

Theodore W Berger¹, Robert E Hampson², Dong Song¹, Anushka Goonawardena², Vasilis Z Marmarelis¹ and Sam A Deadwyler²

LETTER

doi:10.1038/nature11028

Optogenetic stimulation of a hippocampal engram activates fear memory recall

Xu Liu^{1*}, Steve Ramirez^{1*}, Pettie T. Pang¹, Corey B. Puryear¹, Arvind Govindarajan¹, Karl Deisseroth² & Susumu Tonegawa¹

<http://channel.nationalgeographic.com/breakthrough-series/videos/implanting-memories/>

14:39~18:00



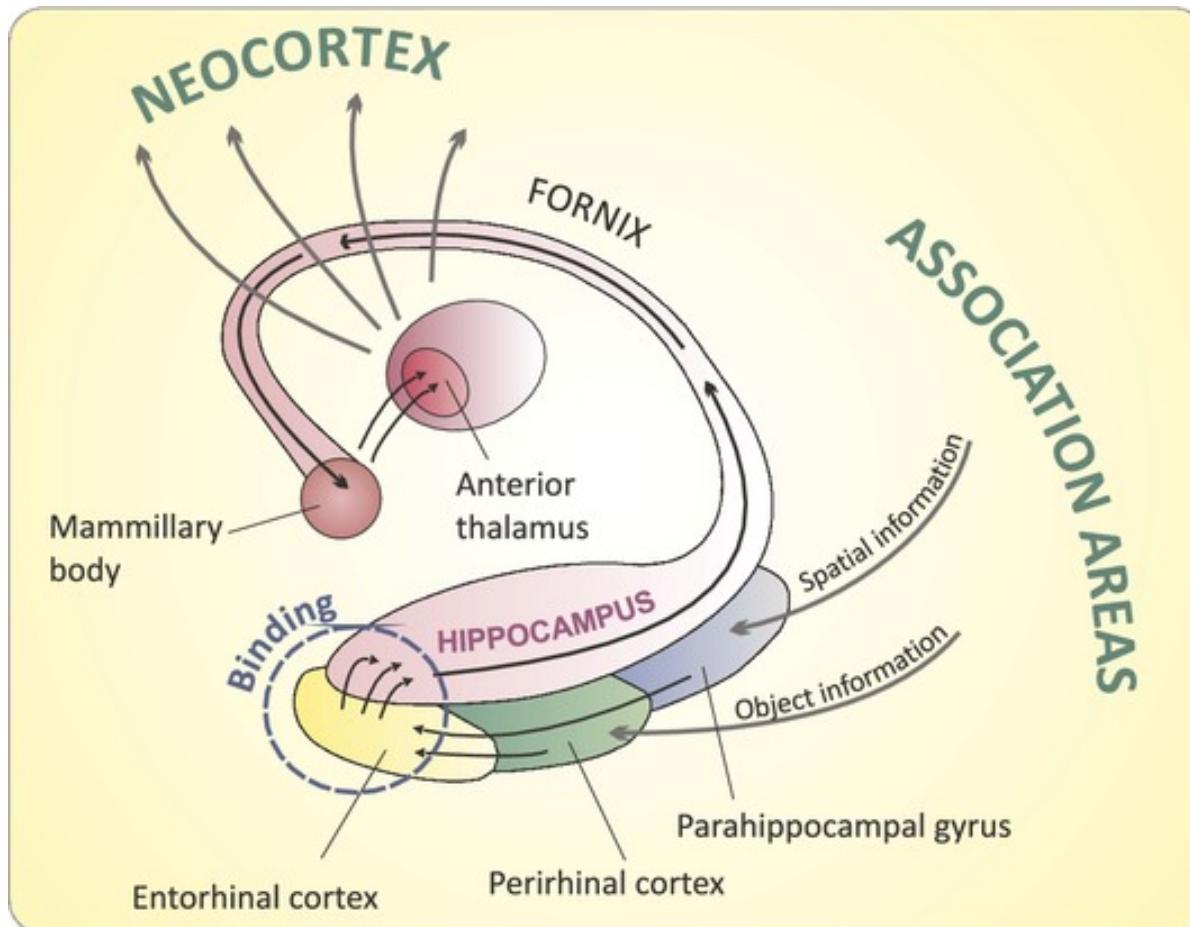
She's purring



Review

- Memory systems
 - Sensory -> Short-term -> Long-term
 - Short-term – limited capacity, limited time
 - Long-term – unlimited capacity, unlimited time
- Amnesia – anterograde vs retrograde
 - HM – anterograde amnesia (and some retrograde)

Anatomy



Tip-of-the-tongue

A feeling that one *knows* a response yet is unable to produce it



Tulving and his cat



Drawing © Ruth Tulving, Courtesy the artist.

Dual-Process Theories of Recognition: Recollection and Familiarity



I enter a friend's room and see on the wall a painting. At first I have the strange, wondering consciousness, 'surely I have seen that before,' but when or how does not become clear. There only clings to the picture a sort of penumbra of familiarity, – when suddenly I exclaim : I have it, it is a copy of part of one of the Fra Angelicos in the Florentine Academy – I recollect it there!

from The Principles of Psychology by
William James

Memory retrieval can be based on recollection
or on familiarity

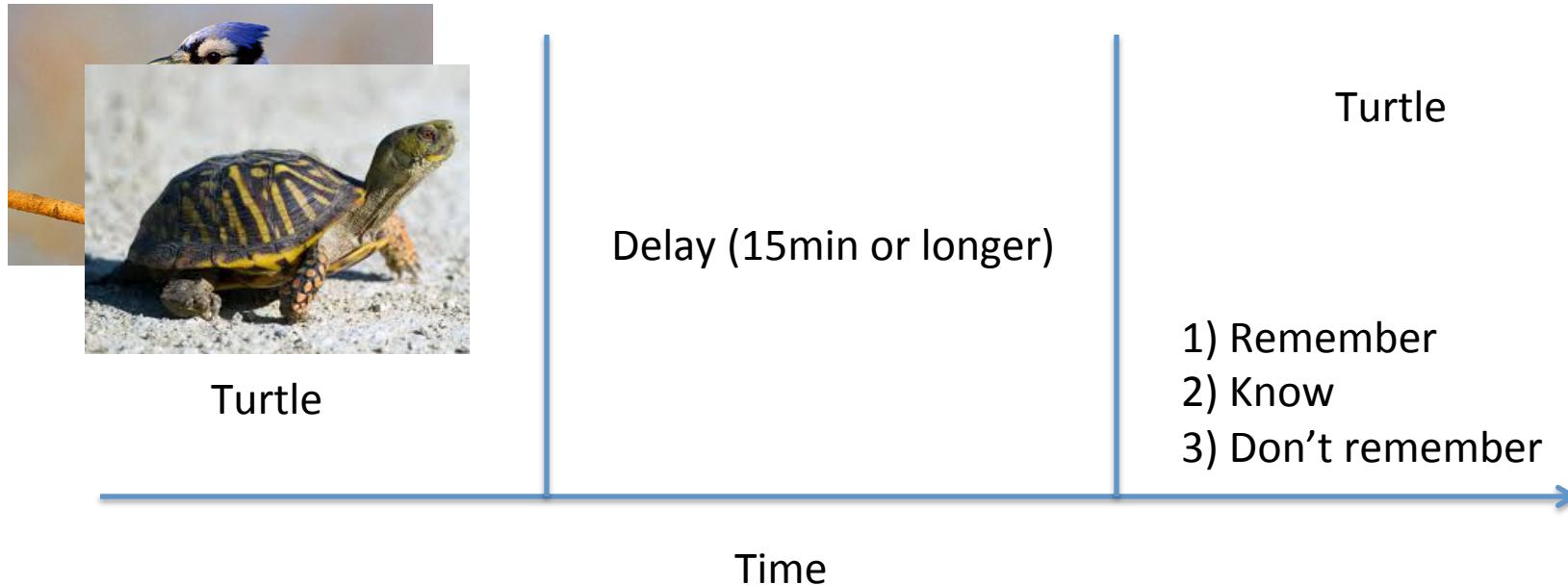
Recollection (R): a relatively slow search process whereby qualitative information about a prior event is retrieved (e.g., when, where etc).

Binary (either recollect or not)

Familiarity (F): a relatively fast process whereby familiarity or a ‘sense of recency’ is used as a basis for recognition (i.e., the item seems familiar, so it probably was studied).

Graded/continuous (e.g., strong or weak feeling of knowing)

Remember/know paradigm

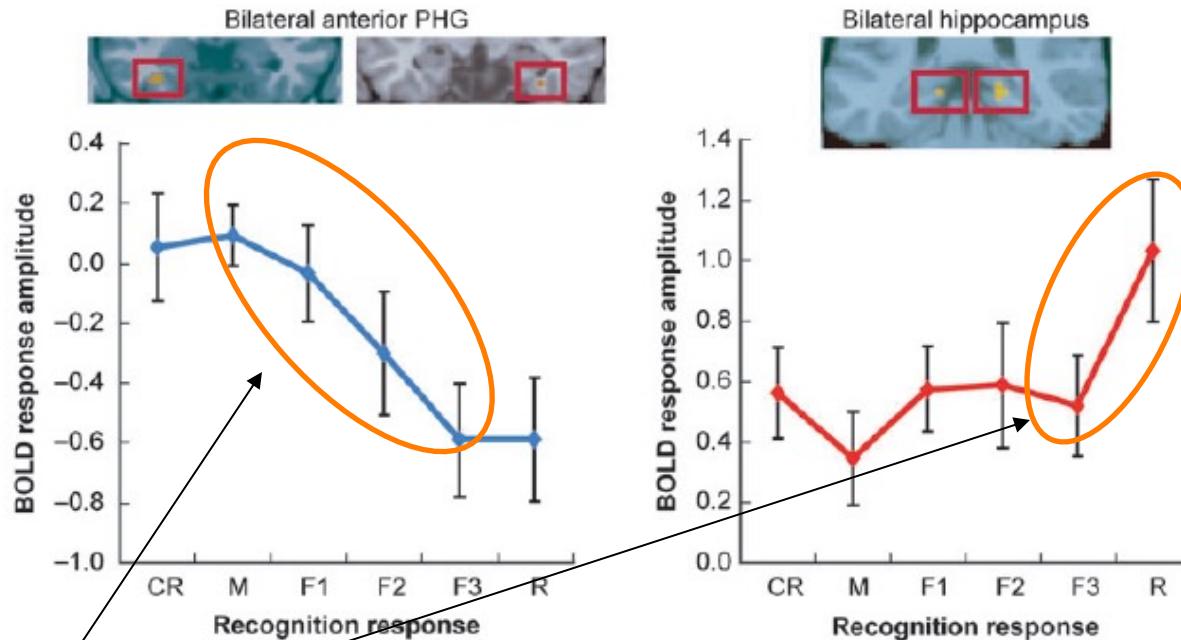


- Remember – can recall details
- Know – know it was presented, but don't remember details

Remember Versus Know

- Remember/Know processes
 - Make R/K judgment for “Old” items
 - *Remember* = consciously recollect details of the item’s presentation
 - *Know* = sure an item was presented, but can’t recall any of the details of presentation
- The two responses are supported by two processes
 - Recollection (remember judgments) and
 - Familiarity (know judgments)

Dissociable neural mechanisms for R & F



Remember (R) and Know (familiarity confidence F1, F2, F3) responses.

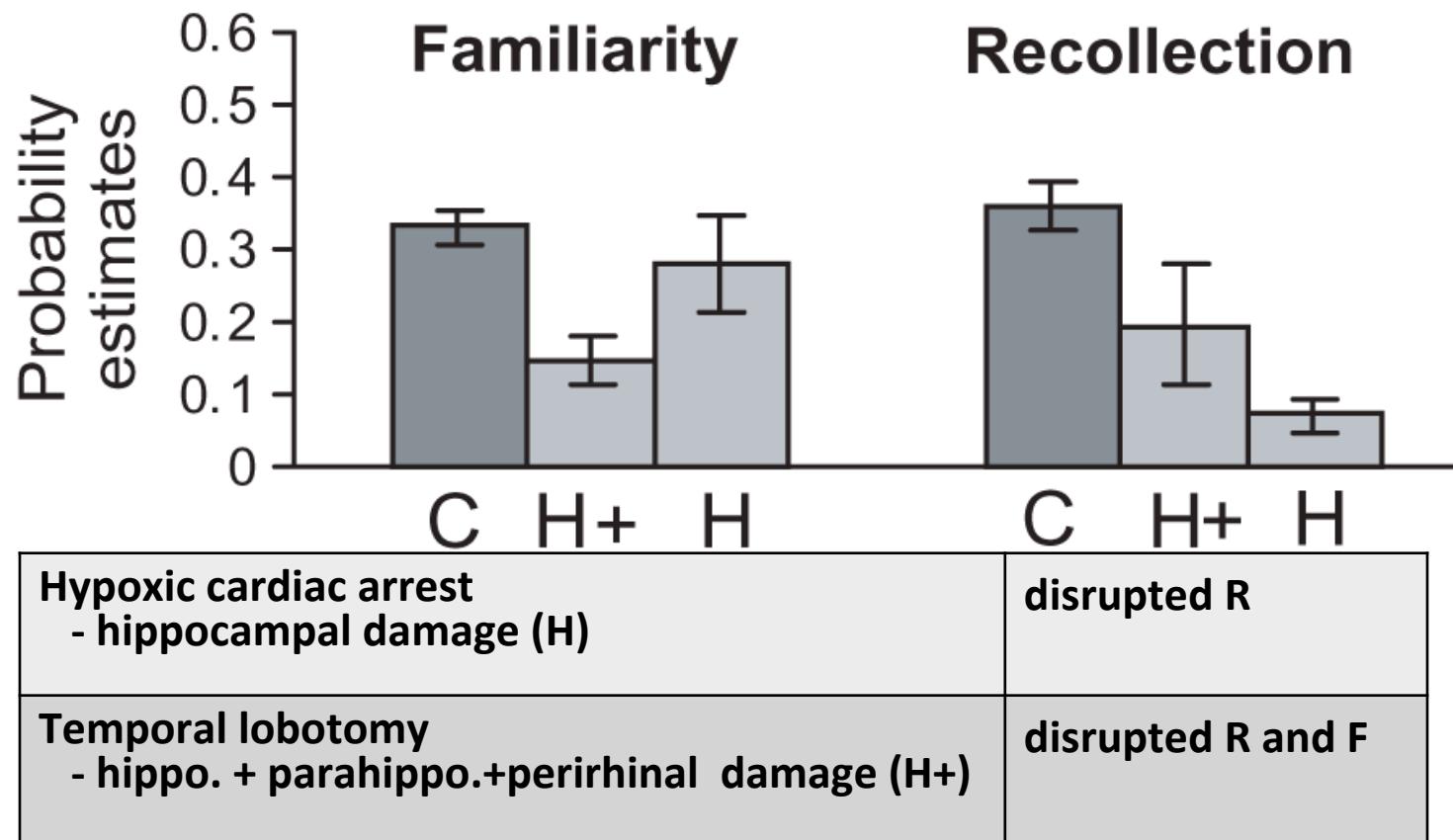
CR: correct rejection of lures; M: missed target

- Hippocampus was related to recollection, but not familiarity
- Parahippocampal gyrus activation scales with subjective familiarity judgments, and was related to familiarity, but not recollection

What about a double dissociation?

- Damage to hippocampus versus damage to parahippocampal gyrus

Hippocampal lesion & damaged recollection



- hippo involved in R,
- parahippo & perirhinal involved in F
- neural dissociation of R & F

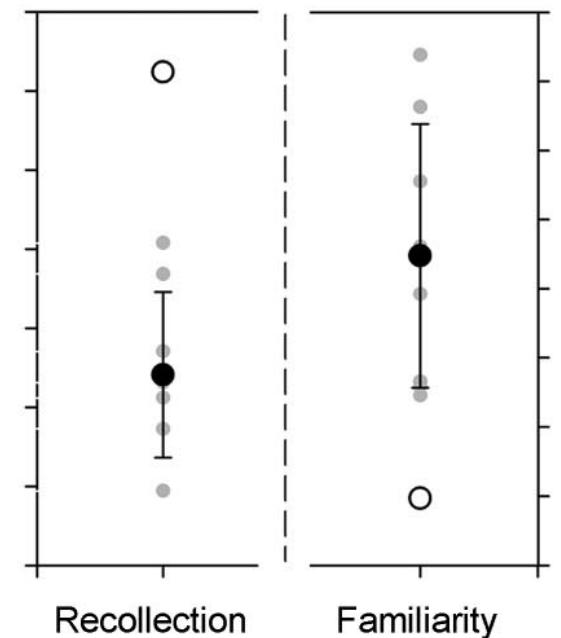
Yonelinas et al. 2002 Nature Neuroscience

Perirhinal Lesions Impair Familiarity But Spare Recollection

Patient NB, resection of a large portion of perirhinal cortex but spared the hippocampus.

Impaired familiarity with intact recollection

Familiarity is dependent on **perirhinal cortex** of MTL



● Individual controls ● Control average ○ NB's score

Overview of R and F

R – slow search, qualitative elaborative info (e.g., when, were, etc), discrete (binary), hippocampal dependent

F – fast, more perceptual item information, graded confidence, perirhinal/parahippo dependent

Tip-of-the-Tongue: may be supported by familiarity in the absence of recollection



By Michael -Roberts

Non-declarative Memory



THE OTHER WEAKEST LINK

YOU WON'T BELIEVE THIS! WE'VE MADE IT POSSIBLE TO STORE A 30-CHARACTER PASSWORD IN A PERSON'S SUBCONSCIOUS MEMORY. BECAUSE THEY LEARN IT IMPLICITLY, THEY DON'T EVEN KNOW THEY KNOW IT!

THE PASSWORD HOLDER COULDN'T TELL YOU WHAT IT WAS IF THEY WANTED TO!



NO STAR POWER BONUS

IN ORDER TO "LEARN" THE PASSWORD, SUBJECTS PLAY THIS GAME WE MADE. THESE DOTS FALL DOWN THE SCREEN, AND THE SUBJECT HAS TO HIT THE CORRESPONDING KEY WHEN IT GETS TO THE BOTTOM.

WE CALL IT
SERIAL INTERCEPTION
SEQUENCE LEARNING!

YOU TWO CAME
UP WITH THIS
YOURSELVES?

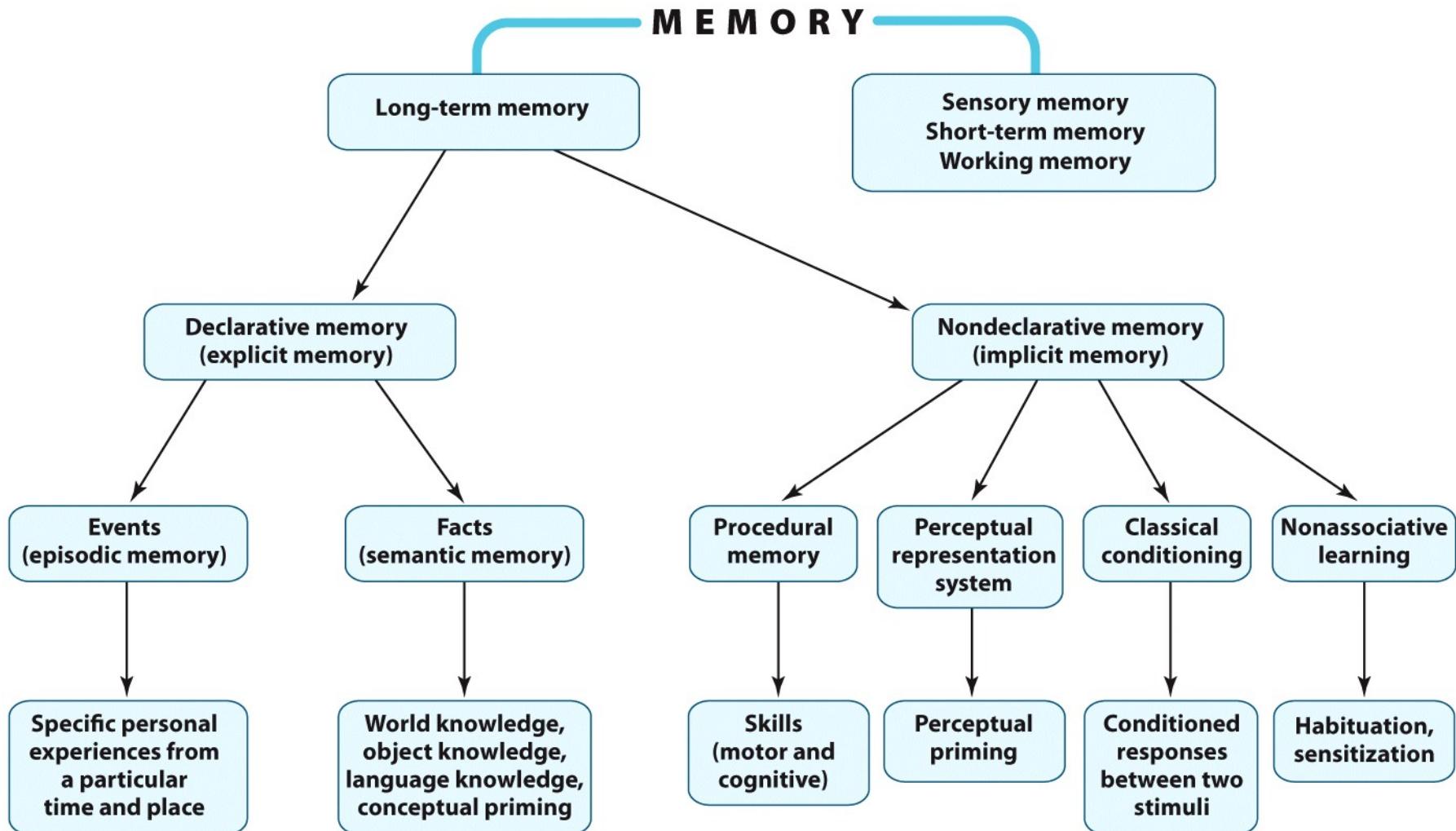
SCI-ENCE.ORG



In SISL task, participants were unable to recall or even recognize short fragments of the planted secret (Bojinov et al., 2012)

Your experience like this? e.g., muscle memory, phone number

Beyond Episodic Memory



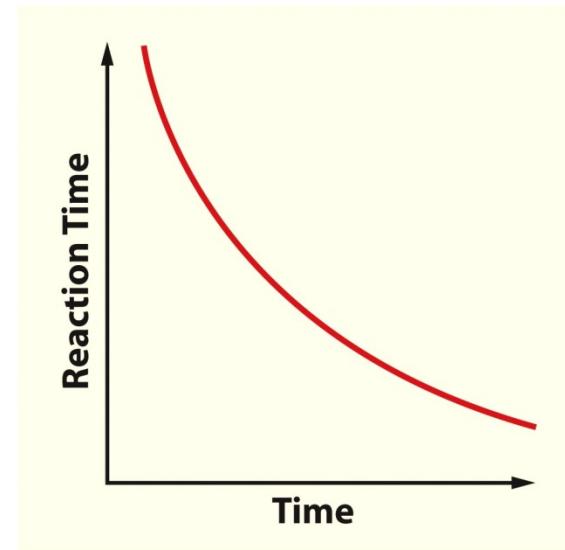
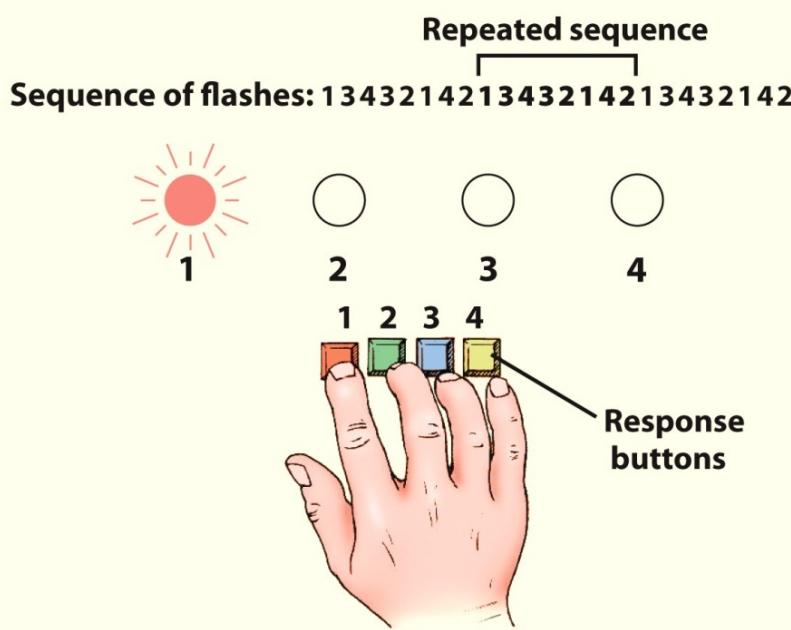
Can amnesics learn new semantic knowledge?

- Some newly acquired knowledge, although more difficult to learn
 - Popular culture: “who is Shrek?”
 - News events: “who is the president of the United States?”
- Maybe semantic memory relies less on medial temporal lobe for encoding.



Can amnesic patients learn procedural skills?

- Serial reaction time task (implicit sequence learning)
- Explicit knowledge not necessary.
- Relies on basal ganglia



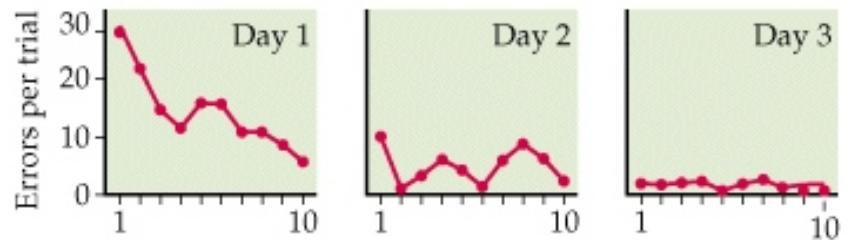
Amnesics improve on task even though cannot report memory of having done it before.

Mirror tracing task in H.M.

- Perceptual-motor skill
- type of procedural learning



(b) Performance of H.M. on mirror-tracing task



- H. M. exhibits intact learning &
- BUT no “conscious” or declarative memory of episode

VOWEL COUNTING TASK

- count number of vowels in each word write it down
- 4 sec /item

rhetoric

adenoid

polliwog

croquet

lacrosse

democrat

clarinet

epitaph

tequila

FRAGMENT COMPLETION TASK

complete the word fragment with the
first word that comes to mind

_o_v__te

_ex_g_

_||_p_e

Iret

_sb __o_

t ui a

How Did You Do in the Vowel Counting Task?

New Words

corvette ?

asbestos ?

hexagon ?

Old Words from Vowel Counting

clarinet ?

tequila ?

ellipse ?

- Increased likelihood of solving the fragments if the words had been studied.
- Example of implicit memory or what is sometimes called priming.

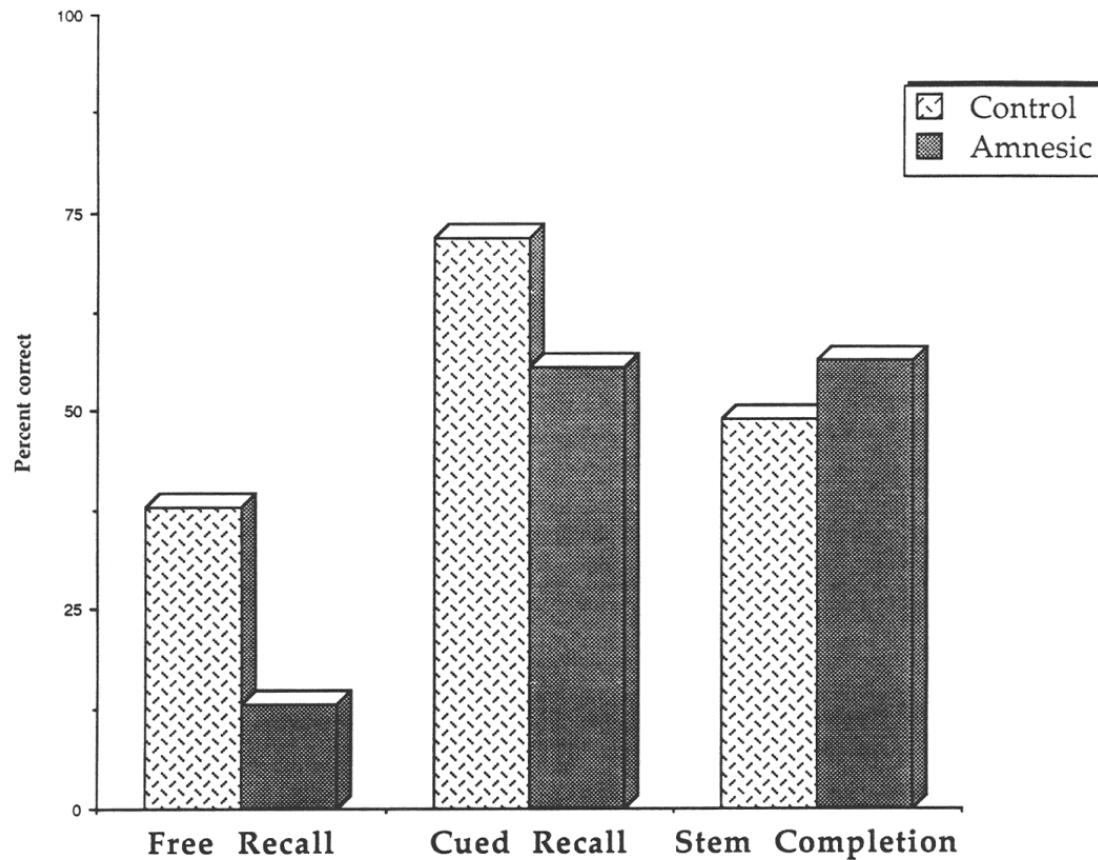
Nondeclarative memory

Explicit memory tests - tasks that explicitly instruct subjects to use memory (e.g., recall, recognition)

Implicit memory tests - tasks that do not explicitly instruct subjects to use memory

- Measure the unconscious influence of experience without asking to recall the past

Priming without awareness

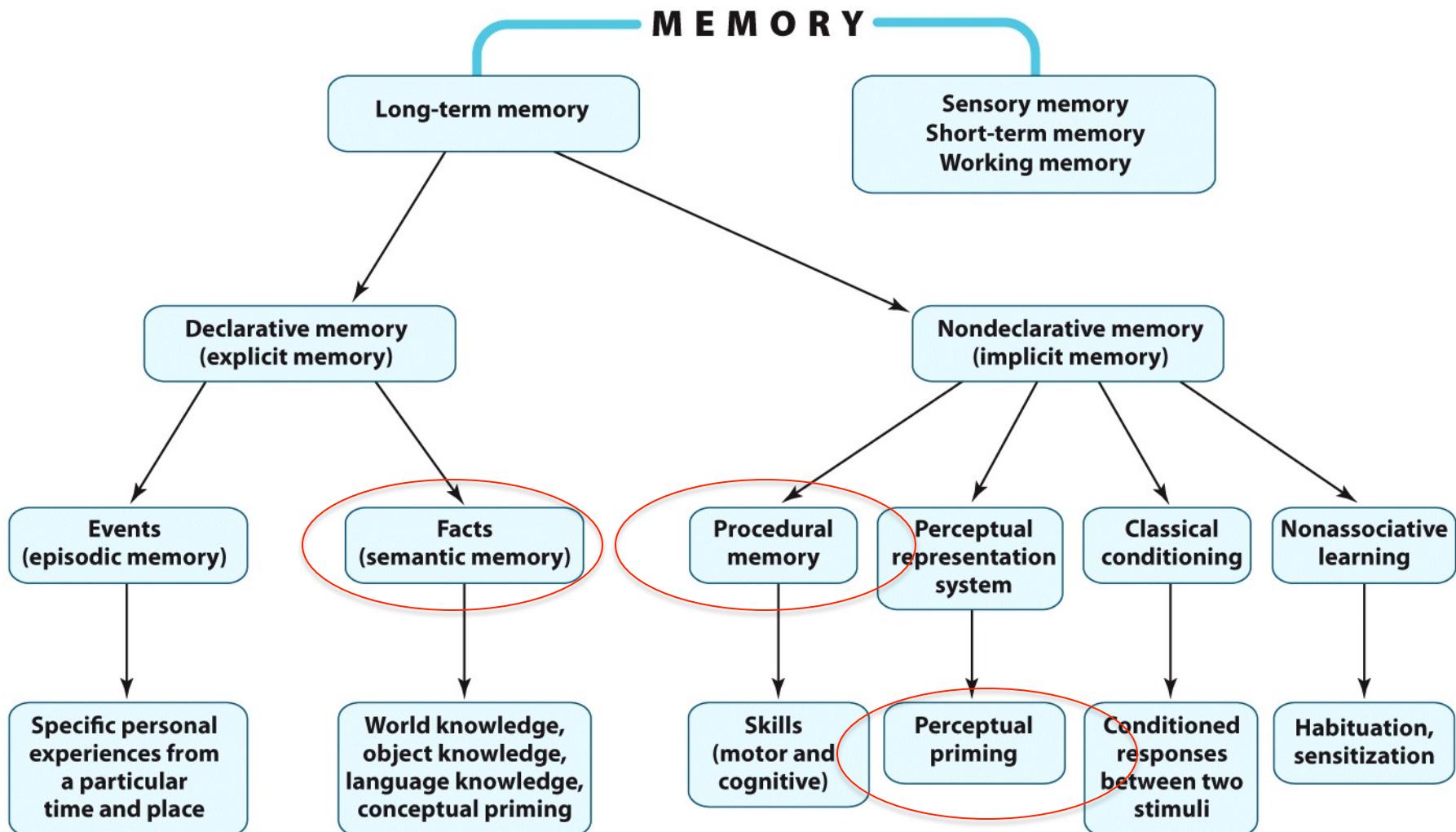


“List everything
you remember”

“List all the
animals that you
remember”

“Complete this
word stem”

Beyond Episodic Memory



Some semantic memory, procedural memory, and semantic priming in Amnesia, suggesting these memory subsystems may be less dependent on MTL

DRM Demo

Singularity

DRM Demo

Did you see it?

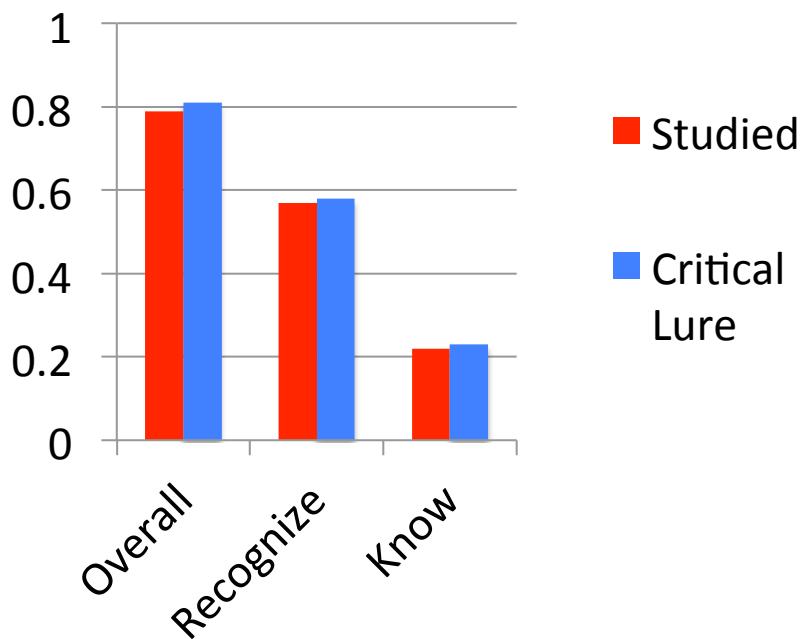
aardvark wake slumber sleep

rest tired awake dream snore
bed eat slumber sound comfort
wake night

DRM Paradigm

(Deese, 1959; Roediger & McDermott, 1995; Roediger & McDermott, 1995)

- **Recall:** ~ 40% recalled “sleep”
- **Recognition:** Remembering the **lure** (*sleep*) during recall strengthened participants memories of the lure during recognition
 - Participants claimed to “remember” the lure rather than merely “know” it had been on the list



False Memories

- Memory is reconstructive
 - Sometimes we may “remember” things that never actually happened
 - And for these “false memories” we may be as confident in them as we are with actual memories
 - We are surprisingly unaware of how unreliable our memory can be and overly confident in the accuracy of our memories

Essentials

- Multiple memory systems
 - Sensory memory, working memory, long term memory
 - Differences in capacity & endurance
- Amnesia
 - MTL and memory
- Recollection vs familiarity
 - Remember versus know
 - Neural substrates: hippocampus versus parahippo & perirhinal
- Beyond episodic memory: implicit memory
- False memory and memory distortion